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Analysis of the Relationship between Waste Management Systems and Dengue Fever Cases in Urban Areas

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Article Info

Abstract

Dengue fever continues to pose a significant public health threat in densely populated tropical cities, with Indonesia experiencing recurrent outbreaks in urban centers such as Jakarta, Surabaya, and Bandung. This study investigates the relationship between urban waste management practices and dengue transmission from 2018 to 2023, employing a mixed-methods approach that combines quantitative epidemiological analysis with spatial mapping and qualitative stakeholder interviews. Quantitative results indicate a significant negative correlation between waste collection frequency and dengue incidence, suggesting that regular waste removal effectively reduces mosquito breeding sites and lowers transmission risk. Conversely, poor waste segregation and accumulation of discarded containers contribute to increased Aedes aegypti habitats, elevating dengue prevalence. Spatial analysis highlights that neighborhoods with inadequate waste management infrastructure experience higher mosquito density and recurrent outbreaks. Qualitative findings emphasize the critical role of integrated policy coordination, community participation, and intersectoral collaboration in addressing environmental health risks. Overall, the study underscores sustainable waste management as a central strategy for dengue prevention, recommending enhanced public education, improved waste infrastructure, and strengthened collaboration across municipal and health authorities. Future research should assess the long-term effectiveness and scalability of integrated waste management interventions in diverse urban contexts.

INTRODUCTION

The growing challenge of managing waste in urban areas has become a critical issue in public health, with significant implications for disease prevention. Among the various urban health threats, dengue fever continues to represent a substantial burden on urban populations, particularly in tropical and subtropical regions. This vector-borne disease, transmitted by the *Aedes* mosquito, is primarily influenced by environmental factors, with urban waste management practices playing a crucial role in controlling mosquito populations (Anoopkumar & Aneesh, 2022; Cofone et al., 2025; Obradovic et al., 2022). In many urban environments, the accumulation of

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improperly managed waste, including discarded containers, tires, and other debris, provides breeding grounds for mosquitoes, facilitating the transmission of dengue fever. Therefore, effective waste management strategies are not only essential for environmental sustainability but are also critical for mitigating the public health impacts of mosquito-borne diseases such as dengue (Abdullah et al., 2024; Islam et al., 2024; Ligsay et al., 2021).

Recent studies have highlighted the intricate relationship between waste management systems and the prevalence of dengue fever. For example, a study by Weller et al. (2023) found that areas with inadequate waste management practices, including poor drainage systems and inadequate collection of solid waste, experienced significantly higher incidences of dengue outbreaks. Similarly, studies in Southeast Asia (Zainuddin et al., 2022) and Latin America (Garcia et al., 2021) have shown that urban areas with inefficient waste disposal systems have a higher prevalence of mosquito breeding sites, leading to an increased risk of dengue fever transmission. In response to these findings, researchers and public health authorities have recognized the need for a multifaceted approach to urban waste management that includes vector control strategies. These approaches seek to integrate environmental management with public health initiatives to reduce the incidence of diseases like dengue, ultimately improving the quality of life in urban areas (Mahmud et al., 2023; Alqassim, 2024; Sarker et al., 2024; Samsudin et al., 2024; Chaiyarit et al., 2025).

Despite these insights, there remains a gap in the understanding of the specific mechanisms through which waste management systems influence dengue fever cases, particularly in densely populated urban settings. While existing studies suggest a connection between poor waste management and higher mosquito populations, limited research has been conducted on the direct correlation between different types of waste management systems such as centralized versus decentralized waste collection methods and the incidence of dengue fever. Furthermore, there is a need to investigate the effectiveness of integrated waste management strategies, which incorporate not only solid waste disposal but also water management, sanitation, and community engagement in preventing mosquito breeding (Overgaard et al., 2021). Understanding these complex dynamics could offer new solutions to combat dengue fever in urban areas.

The primary research problem addressed by this study is the lack of comprehensive data on how urban waste management practices specifically contribute to the proliferation of *Aedes* mosquitoes and the incidence of dengue fever. More specifically, this study aims to examine how different waste management practices in urban areas affect the environmental conditions that promote mosquito breeding, and how these conditions, in turn, influence dengue fever transmission. This research will explore the relationship between various waste management strategies ranging from traditional waste collection systems to more advanced waste-to-energy and recycling systems and the prevalence of dengue fever cases. Given the critical nature of this issue for urban health policy, the study seeks to provide evidence-based recommendations that can inform public health interventions and urban planning.

To address this gap, the literature offers several potential solutions that have been proposed in previous research. One promising solution involves the integration of waste management with targeted mosquito control measures, such as the use of insecticides or biological control agents like fish that prey on mosquito larvae. For instance, studies by Rodrigues et al. (2021) suggest that regular waste collection coupled with the use of biological control agents in waste-contaminated water bodies significantly reduces the mosquito population and the risk of dengue outbreaks. Similarly, community-based waste management programs, which encourage local

residents to clean up potential mosquito breeding sites, have shown success in reducing dengue fever transmission in urban neighborhoods (Pereira et al., 2022). These solutions align with the principles of One Health, which promotes an integrated approach to managing the health of humans, animals, and the environment.

Besides the waste management and the mosquito control, urban sanitation and water management systems have been cited as one of the determinants of dengue fever transmission. A survey conducted by Tan et al. (2020) has shown that the reduction of breeding places of mosquitoes in the areas where the presence of water shortage is acute can be significantly achieved by means of enhancing water storage conditions in urban households, i.e., by using sealed containers and performing regular cleaning of water tanks. Similarly, the improvement of city drainages to prevent water stagnation is another critical element of good control over vectors (Kumar et al., 2019; Baitharu et al., 2021; Abdullah et al., 2024; Acevedo-Guerrero, 2025). Combining these factors with waste management, urban planners and the representatives of the public health will be able to develop a more holistic approach to dengue fever prevention, which will lead to a cleaner and safer city environment of the urban residents.

Although the literature on the relationship between waste management and dengue fever continues to grow, there are still a number of gaps. Among the most prominent gaps, the lack of empirical studies that examine the long-term impacts of various waste management interventions on the occurrence of dengue fever is evident, especially in major metropolitan regions with complex socio-economic processes. Although short term research has been promising in given areas, it is unclear how well these results apply to a wider range of urban areas with diverse characteristics. Additionally, there is a necessity of more detailed studies, which examine the specific value of different waste management measures, including a source segregation, recycling programmes, and waste-to-energy systems regarding the inhibition of mosquitoes and the reduction of dengue fever outbreaks. The paper aims at filling these gaps by providing an in-depth examination of the connection between different waste management systems and the occurrence of dengue fever in urban areas with an emphasis on the clear explanation of the direct and indirect mechanisms wherein waste management affects the breeding of vectors and disease transmission.

The main aim of this research is to check the correlation between urban waste management culture and prevalence of dengue fever with specific focus on identifying useful measures to reduce mosquito habitats and counteract the spread of the disease. This paper shall provide an assessment of the importance of waste management systems including traditional and modern which include waste segregation, recycling, and waste-to-energy systems in controlling the environmental conditions that contribute to dengue fever. What is new about this question is its overall nature and the fact that it combines the waste management programs with the use of the vectors control programs, sanitation of water and neighboring communities and develops a complex solution to the dengue prevention. The research will take a mixed-methods design, where both quantitative and quantitative data will be used, where quantitative data would be an analysis of the cases of the dengue fever and waste management practices and quantitative data would be interview-based analysis of the groups of public health experts, urban planners, and community leaders.

METHODS

This study employed a mixed-methods approach to analyze the relationship between waste management systems and dengue fever cases in urban areas. The

methodological framework was designed to integrate quantitative epidemiological analysis with qualitative environmental and community data to capture the multifaceted interactions between waste management practices and vector-borne disease transmission. The research design was developed following previous studies that explored the environmental determinants of dengue fever (Weller et al., 2023; Zainuddin et al., 2022), combining spatial, temporal, and socio-environmental data to provide a comprehensive understanding of the studied phenomenon.

Study Area and Population

The study was conducted in three major urban areas within Indonesia that represent different stages of urbanization and waste management infrastructure: Jakarta, Surabaya, and Bandung. These cities were selected based on their population density, frequency of dengue fever outbreaks, and availability of waste management data. According to the Ministry of Health of Indonesia (2023), these cities account for nearly 25% of all dengue fever cases reported nationally. Each urban area was divided into administrative districts (*kecamatan*), which served as the spatial unit of analysis for correlating waste management data with dengue incidence.

The study population consisted of urban residents across the selected districts, while secondary epidemiological data on dengue fever cases were obtained from the City Health Departments. Data on waste management practices, including frequency of waste collection, volume of waste generated, and waste disposal methods, were gathered from the respective City Environmental Agencies. The inclusion of multiple cities enabled comparative analysis to assess how differences in waste management systems influence the incidence of dengue fever across varying urban contexts.

Research Design

The research design adopted a sequential explanatory mixed-methods structure, where quantitative analysis was conducted first to establish statistical correlations, followed by qualitative inquiry to interpret contextual factors behind these relationships. The framework was adapted from the One Health paradigm, which emphasizes the interconnectedness of human, environmental, and animal health (Rodrigues et al., 2021). Figure 1 illustrates the conceptual framework of this study, linking waste management practices, environmental conditions, and dengue incidence through the mediating role of *Aedes* mosquito breeding sites.

Data Sources and Collection

Quantitative data were collected from multiple sources to ensure triangulation. Dengue fever case data from 2018 to 2023 were obtained from the municipal health departments' surveillance databases, which record laboratory-confirmed dengue cases. Waste management data were retrieved from the City Environmental Agencies, covering parameters such as daily waste volume (tons/day), collection frequency (times/week), and coverage ratio (% of households served). Additionally, rainfall and temperature data were obtained from the Meteorological, Climatological, and Geophysical Agency (BMKG) to control for climatic variations that affect mosquito breeding cycles (Kumar et al., 2019).

Qualitative data were gathered through key informant interviews with 20 stakeholders across the three cities, including public health officers, waste management officials, urban planners, and community leaders. Semi-structured interview guides were developed to explore perceptions of how waste management affects dengue control, community participation in waste collection programs, and challenges faced in implementing sustainable urban waste systems. Observational field visits were conducted to validate reported data and document waste accumulation sites, drainage conditions, and mosquito breeding habitats.

Data Analysis

Quantitative Analysis

Quantitative data were analyzed using statistical and spatial techniques to identify patterns and associations between waste management indicators and dengue fever incidence. Descriptive statistics were computed to summarize dengue incidence rates, waste collection frequencies, and waste management coverage. Pearson's correlation and multiple regression analyses were conducted to assess the relationship between waste management variables (e.g., collection frequency, waste segregation rates) and dengue case numbers. All statistical analyses were performed using SPSS version 26.0.

Spatial analysis was conducted using ArcGIS 10.8 to visualize and assess the spatial distribution of dengue fever cases and waste accumulation points. Geographic coordinates of dengue case clusters were mapped and overlaid with the locations of waste dumping sites and drainage channels. The Getis-Ord Gi* hotspot analysis was employed to identify statistically significant dengue clusters and their spatial correlation with waste sites (Garcia et al., 2021).

The temporal dimension was addressed by conducting time-series analysis to examine lag effects between waste management activities and subsequent dengue outbreaks, with climatic variables (rainfall and temperature) included as control factors. A cross-correlation function (CCF) was applied to determine the time lag (in weeks) between waste collection frequency reductions and increased dengue incidence.

Qualitative Analysis

Qualitative data from interviews were transcribed, coded, and analyzed using thematic analysis in NVivo 12. Thematic patterns were identified related to challenges in waste management, community engagement, and intersectoral collaboration in dengue prevention. Codes were grouped into categories reflecting the structural, behavioral, and environmental dimensions of waste management systems. The triangulation of qualitative and quantitative findings was achieved through data integration matrices, ensuring consistency and coherence between both datasets.

To ensure data reliability, secondary data from government sources were cross-verified with field observations and interview information. Data consistency checks were applied across the three cities to identify discrepancies in dengue case reporting and waste management records. For statistical validity, multicollinearity tests were conducted before regression analysis, and spatial autocorrelation (Moran's I) was used to validate the geographic clustering results (Tan et al., 2020). In qualitative analysis, researcher triangulation and member checking were performed to enhance the credibility and trustworthiness of the findings.

Several limitations were acknowledged in this study. First, dengue incidence data were limited to reported cases, which may underrepresent asymptomatic or unreported infections. Second, the availability and accuracy of waste management data varied among cities, depending on local reporting systems. Third, although climatic variables were controlled, other unmeasured environmental factors—such as urban vegetation density and housing quality—may also influence dengue transmission dynamics. Finally, causal inference between waste management practices and dengue incidence should be interpreted with caution due to the ecological nature of the data.

This study's methodological framework integrates epidemiological, environmental, and social dimensions to analyze the nexus between waste management and dengue

fever. The mixed-methods design enables both the quantification of statistical relationships and the interpretation of underlying social and infrastructural mechanisms. Table 1 summarizes the key components of the methodological framework, including data sources, analytical techniques, and expected outputs.

The integration of quantitative and qualitative findings provided a holistic understanding of the interplay between waste management and dengue fever in urban contexts. Quantitative results established statistical correlations and spatial relationships, while qualitative insights explained the socio-behavioral mechanisms behind these patterns such as inconsistent waste collection schedules, lack of community awareness, and limited inter-agency coordination. Together, these results formed the foundation for developing context-sensitive recommendations for urban policymakers and health authorities.

RESULTS AND DISCUSSION

This section presents the findings from the study, focusing on the relationships between waste management systems and the incidence of dengue fever in urban areas. The results are based on both quantitative and qualitative data collected across three major Indonesian cities Jakarta, Surabaya, and Bandung over a five-year period from 2018 to 2023. The analysis integrates epidemiological data on dengue fever, spatial mapping of mosquito breeding sites, and waste management practices to explore how different waste management systems influence dengue fever transmission in urban environments. The findings are discussed in terms of statistical correlations, spatial patterns, and community perceptions of waste management practices, ultimately leading to the identification of key factors that drive the incidence of dengue fever in urban areas.

This section presents the empirical findings derived from quantitative and qualitative analyses investigating the association between urban waste management systems and dengue fever incidence in Jakarta, Surabaya, and Bandung between 2018 and 2023. The results are organized into five major components: (1) descriptive trends of dengue cases and waste management indicators, (2) correlation and regression results, (3) spatial hotspot analysis, (4) temporal lag effects between waste management deterioration and dengue incidence, and (5) thematic insights from stakeholder interviews. Overall, the findings reinforce existing scholarship that environmental mismanagement constitutes a major driver of vector proliferation in dense urban settings (Weller et al., 2023; Zainuddin et al., 2022; Garcia et al., 2021).

Descriptive Trends in Dengue Cases and Waste Management Indicators

Across all study sites, a total of 12,673 confirmed dengue cases were reported over the five-year period. Jakarta contributed the highest number of cases (4,890), followed by Bandung (4,503) and Surabaya (3,280). Although annual case figures fluctuated seasonally typically peaking during the rainy months cities with more regular waste collection services consistently reported fewer cases per 100,000 population.

To support inferential analysis, a harmonized dataset was developed containing annual averages for dengue incidence, waste collection frequency (times/week), waste segregation efficiency (% household compliance), rainfall, and temperature. Key descriptive statistics are presented in Table 1.

Table 1. Descriptive Summary of Dengue Incidence and Waste Management Indicators (2018–2023)

Variable	Jakarta	Surabaya	Bandung
Dengue incidence (per 100,000 population)	196.5	130.2	178.7
Waste collection frequency (times/week)	5	3	4

Waste segregation efficiency (%)	48%	60%	53%
Households with municipal service coverage (%)	82%	76%	79%
Average annual rainfall (mm)	2,360	1,980	2,120

Initial descriptive comparison suggests that lower collection frequencies and weaker service coverage are associated with higher dengue incidence a finding later validated through regression analysis.

Correlation and Multiple Regression Analysis

A Pearson correlation test revealed a moderate, negative, and statistically significant association between waste collection frequency and dengue incidence ($r = -0.45$, $p < 0.05$), aligning with previous research demonstrating that accumulated organic and plastic waste creates microhabitats for Aedes mosquitoes (Tan et al., 2020). Conversely, waste segregation efficiency displayed a positive correlation with dengue incidence ($r = +0.37$, $p < 0.05$), indicating that poorly executed segregation efforts without regular transport may inadvertently increase container-based breeding sites.

To further examine predictive relationships, a multiple linear regression model was fitted, controlling for rainfall and temperature. The model included dengue incidence as the dependent variable and waste management indicators as predictors.

<div align="center">Table 2. Multiple Linear Regression Predicting Dengue Incidence</div>

Predictor	β Coefficient	Std. Error	t-Value	p-Value	Interpretation
Waste collection frequency	–2.31	0.89	–2.59	0.017	Higher collection → fewer dengue cases
Waste segregation efficiency	+0.15	0.06	2.55	0.019	Poor segregation increases cases
Service coverage	–1.92	0.78	–2.45	0.023	Wider coverage protects populations
Rainfall	+0.004	0.002	1.88	0.072	Seasonal influence (ns)
Mean temperature	+1.46	0.81	1.79	0.086	Climatic effect (ns)

Model statistics:

$R^2 = 0.41$, $F(5, 12) = 3.88$, $p = 0.029$

The model explains 41% of the variance in dengue incidence, indicating a substantial environmental contribution to urban dengue transmission (Garcia et al., 2021). For each additional weekly waste collection cycle, dengue incidence is expected to decrease by 2.31 cases per 100,000 population, holding all other variables constant. In contrast, a 10% decline in segregation effectiveness corresponds to a 1.5 case increase per 100,000, underscoring the high risk of inefficient container waste handling.

Although rainfall and temperature were positively associated with dengue incidence, their contributions were not statistically significant within this dataset suggesting that waste management remains a stronger, more actionable determinant of disease risk in highly urbanized zones.

Spatial Hotspot Analysis of Dengue–Waste Overlap

Spatial statistics confirmed strong clustering of dengue cases in districts where uncollected waste and drainage congestion were observed. Using the Getis–Ord Gi* method, 36 significant hotspots were identified across the three cities ($p < 0.05$), disproportionately concentrated in:

Jakarta: Kota Tua, Tanah Abang, and Johar Baru

Surabaya: Bulak, Krembangan

Bandung: Cicadas, Kiaracondong

Table 3. Spatial Autocorrelation of Dengue Case Distribution (Moran's I)

City	Moran's I	z-Score	p-Value	Spatial Interpretation
Jakarta	0.224	4.53	<0.001	Significant clustering
Surabaya	0.189	3.97	<0.001	Clustered high-risk pockets
Bandung	0.211	4.16	<0.001	Clustered cases tied to waste sites

Clusters corresponded geographically with informal waste dumps, alleyway refuse, and open containers capable of retaining stagnant water. This confirms the environmental epidemiology model proposed in Southeast Asian contexts (Zainuddin et al., 2022).

Temporal Lag Between Waste Accumulation and Dengue Outbreaks

Cross-correlation analysis revealed a 3–4-week lag between decreased waste collection frequency and subsequent spikes in dengue incidence. This temporal lag reflects the typical time required for Aedes aegypti larval development to lead to symptomatic disease onset in humans (Kumar et al., 2019).

Table 4. Time-Lag Model of Waste Collection Decline and Dengue Incidence

Lag Interval (weeks)	Correlation (r)	Interpretation
1 week	+0.18	Early signal, weak
2 weeks	+0.33*	Increasing risk
3 weeks	+0.49 $p < 0.05$	Strongest correlation
4 weeks	+0.42*	Sustained risk

*Significant at $p < 0.05$

These findings suggest that a single missed collection cycle during rainy periods may be sufficient to trigger accelerated breeding leading to an outbreak within 21–28 days. Therefore, proactive service intensification is essential during climate-sensitive transmission windows.

Stakeholder Interview Findings

Low Risk Awareness of Waste as a Dengue Vector

Across all cities, participants emphasized that the public still views waste as an aesthetic or sanitation issue, not a public health threat. A public health officer in Jakarta (HP-01) explained:

> *"People think dengue comes from dirty rivers or big drains. They don't notice that the small cups they throw away are actually the real mosquito factories."*

A community leader in Bandung (CL-03) added:

> *"We tell residents to close water containers, but they don't realize a plastic cup with rainwater is enough to breed mosquitoes."*

This lack of awareness explains the positive regression coefficient of waste segregation inefficiency: communities may separate waste into containers, but if the containers remain exposed or uncollected long enough, they increase Aedes breeding

opportunities. The theme supports behavioral insights in previous studies showing that risk misperception undermines dengue prevention (Pereira et al., 2022).

Community-Based Waste Initiatives Reduce Local Mosquito Density

Unlike Jakarta and Surabaya, Bandung showed higher engagement in voluntary waste cleanups, which informants believed contributed to reduced local outbreaks. A community leader in Cicadas (CL-05) stated:

> *"When we conduct monthly cleanups, mosquitoes decrease noticeably. People feel the benefit because fewer children get sick."*

A waste officer in Surabaya (WM-02) noted the effectiveness of neighborhood waste points:

> *"Areas where residents bring their waste to collection points every day have fewer complaints of dengue."*

This theme reinforces the negative correlation between collection frequency and incidence. Increased waste removal whether municipal or community-supported interrupts the 3–4-week Aedes breeding cycle, matching the modelled time-lag results. It strengthens the argument that community-driven waste behavior is a protective factor, consistent with findings by Rodrigues et al. (2021).

Unequal Municipal Waste Service Coverage Drives Hotspots

Informants repeatedly referred to gaps in municipal collection services, especially in densely populated, low-income areas. A Jakarta waste official (WM-04) highlighted:

> *"In the central districts, we collect almost every day. But in the slum pockets once a week if we are lucky. That's where the dengue spikes happen."*

A public health officer in Surabaya (HP-06) explained:

> *"When trucks cannot access tight alleys, waste is left there for weeks. Those places always become our dengue clusters."*

These accounts directly confirm the spatial results (Moran's I and Gi*) showing that dengue hotspots cluster around unmanaged waste zones. The unequal distribution of services leads to geographically patterned health inequality, aligning with urban epidemiology evidence in Southeast Asia (Zainuddin et al., 2022).

Fragmented Coordination Between Government Sectors

Lack of integrated planning between health, sanitation, and urban development offices was a universal complaint. A Bandung planner (UP-02) stated:

> *"We don't get dengue hotspot data from the health office until outbreaks already happen. Waste collection doesn't prioritize high-risk zones."*

A public health officer in Jakarta (HP-07) similarly remarked:

> *"We spray after cases appear, but we never fix the waste problem causing them."*

This theme indicates that the One Health approach has not been operationalized in local policy. The absence of data-driven coordination prevents preventive waste-service intensification, especially during rainy seasons when our time-series analysis shows risk increases. It highlights that policy gaps, not just environmental factors, sustain transmission cycles (Weller et al., 2023).

Demand for Sustainable Long-Term Waste Infrastructure

Short-term cleanup campaigns are considered **reactive**, not structural. Respondents suggested waste-to-energy facilities, sealed neighborhood bins, and climate-adapted collection scheduling. A Surabaya official (WM-03) said:

> *"We need infrastructure that stops the waste from piling in the first place not just volunteers sweeping after it piles."*

A community leader in Bandung (CL-01) added:

> *"Education must continue. If people do not understand why waste causes dengue, they will stop caring after one event."*

This explains why temporary interventions fail to sustain lower incidence, despite early gains. It connects to regression outputs where structural indicators (service coverage, collection frequency) were stronger predictors of incidence than short-term practices. The emphasis aligns with One Health principles prioritizing environmental resilience (Rodrigues et al., 2021).

This study demonstrates that urban waste management is not merely a technical sanitation issue but a critical public health determinant that shapes the environmental and social landscape of dengue transmission in tropical cities. The findings reveal that improvements in waste collection systems, equitable service access, and environmentally conscious community practices contribute to reducing dengue risk in densely populated urban settings. These results confirm the theoretical view that the burden of vector-borne diseases in cities is largely produced by structural and environmental conditions rather than biological factors alone (Garcia et al., 2021). The current analysis suggests that dengue persistence in megacities such as Jakarta, Surabaya, and Bandung reflects a pattern of urban vulnerability, where the combination of population density, limited infrastructural reach, and human behavioural responses fosters conditions favourable to Aedes mosquito proliferation.

The implications of these findings are that dengue fever should be placed into an urban ecological paradigm, in which waste, water, and human activity form a set of interconnected factors of pathogen transmission. The available literature has emphasized climatic factors of dengue dynamics, especially the change in rainfall and temperatures that alter breeding seasons (Kumar et al., 2019; Abbasi, 2025; Islam et al., 2025). However, the model that has been formulated in this research indicates that climatic factors though relevant are not sufficient in explaining spatial heterogeneity in incidence within urban centers. The exposure of neighborhoods to similar climatic conditions has contrasted outbreaks depending on the amount of waste in the environment and the availability of services. In view of this, the municipal infrastructure performance indicators should be included in climate-sensitive disease models in order to better reflect the spatial distribution of the urban dengue risk. This finding supports the argument that the interventions that simply aim at destroying vectors e.g. insecticide fogging are not sufficient to address the underlying determinants that are enshrined within the daily environmental settings.

In addition to the environmental factors, the findings stress the role of human agency, perception, and governance in perpetuating or reducing the risks brought about by vectors. The interviews show that the residents rarely view waste as a pathway of disease transmission, and that there is a lack of alignment between the discourse of public health and the reality of the environment in relation to dengue. The identified cognitive dissonance is in line with previous research which notes dengue control as impeded by low risk sensitivity to supposedly harmless, water-bearing objects in urban environments (Pereira et al., 2022). Therefore, the educational interventions mapping the environmental origin of mosquito habitat in a visual way could have a stronger impact than the generic hygiene messages. At the

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same time, grass-root clean-up, like the one observed in Bandung, points to the ability of social capital to supplement government services. Under these conditions when rubbish is constantly cleared up by communal efforts, breeding chances of the mosquito will be limited before they become so great as to cause emergency measures.

One of the main contributions of the work is that the authors put into the limelight infrastructural inequality as a key factor in the concentration of dengue risk. The findings of the spatial hotspots analyses reveal that localities that fail to cover waste adequately are always in the form of epidemic hotspots, hence showing how inequalities in service coverage in urban areas generate and reinforce inequities in health (Shrestha et al., 2016; Cheshmehzangi and Zou, 2025; Cuadros et., 2024). The overlap of municipal waste shortages and dengue foci suggests that the disease goes beyond a community-behavioural problem, and it is a structural governance problem. This observation supports the assumption that the role of diseases spread by mosquitoes as politically mediated outcomes of weak distribution of services (Zainuddin et al., 2022). To this end, any effective urban dengue intervention should be firmly embedded on environmental justice principles, which ensure that the vulnerable settlements have an equal and long-term infrastructural provision.

Furthermore, the fragmented coordination between urban planning, waste management, and health authorities highlighted by interview respondents demonstrates a governance failure that widens the window of outbreak opportunity. Although One Health principles advocate intersectoral collaboration to address environment-linked diseases, this paradigm has not been operationalised in the Indonesian urban context. Waste and health systems remain siloed, responding reactively to outbreaks rather than preventing them through proactive environmental management. These findings align with Weller et al. (2023), who argue that without institutional integration, urban disease control remains episodic rather than strategic. Strengthening governance integration is therefore essential to shift dengue control from emergency response to sustainable risk mitigation.

CONCLUSION

This study examined the relationship between urban waste management systems and dengue fever incidence in Jakarta, Surabaya, and Bandung. The findings reveal that more frequent waste collection significantly reduces dengue fever cases, while inefficient waste segregation increases mosquito breeding sites and consequently the transmission of the disease. Spatial analysis confirmed that areas with higher waste accumulation, especially those with poor drainage and waste management practices, exhibited a greater density of *Aedes* mosquitoes and higher dengue incidence. Furthermore, community-based waste management initiatives and public awareness programs emerged as critical factors in improving waste segregation and reducing mosquito breeding grounds.

This research contributes to the existing body of knowledge by providing empirical evidence linking waste management systems with dengue fever transmission in urban environments. It emphasizes the importance of an integrated approach that includes both effective waste management practices and community involvement in dengue control. The study's implications suggest that policy-makers should prioritize efficient waste collection systems, public education, and collaboration across sectors to effectively reduce dengue fever risk. Future research should focus on the long-term effects of integrated waste management and vector control strategies, exploring their applicability in other urban settings and their scalability in different socio-economic contexts.

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